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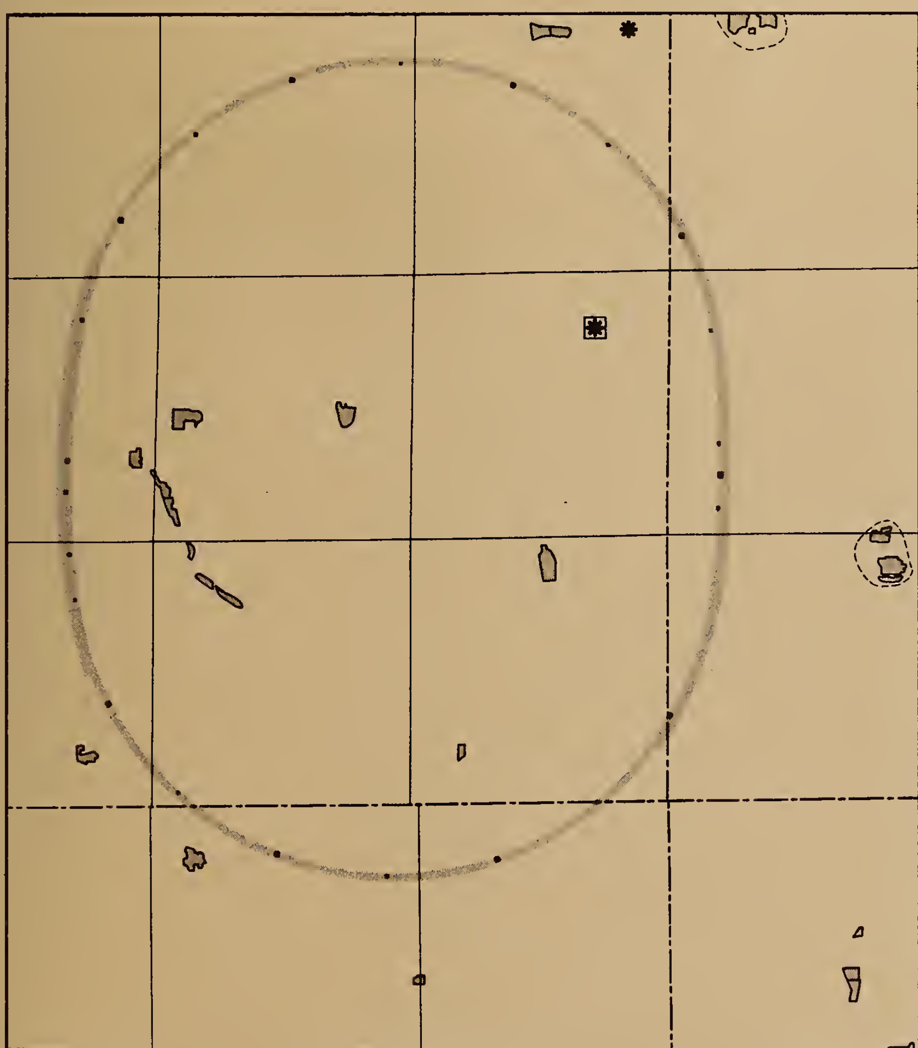
DISPOSAL ALTERNATIVES FOR MATERIAL TO BE EXCAVATED FROM THE PROPOSED SITE OF THE SUPERCONDUCTING SUPER COLLIDER IN ILLINOIS



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DISPOSAL ALTERNATIVES FOR MATERIAL TO BE EXCAVATED FROM THE PROPOSED SITE OF THE SUPERCONDUCTING SUPER COLLIDER IN ILLINOIS

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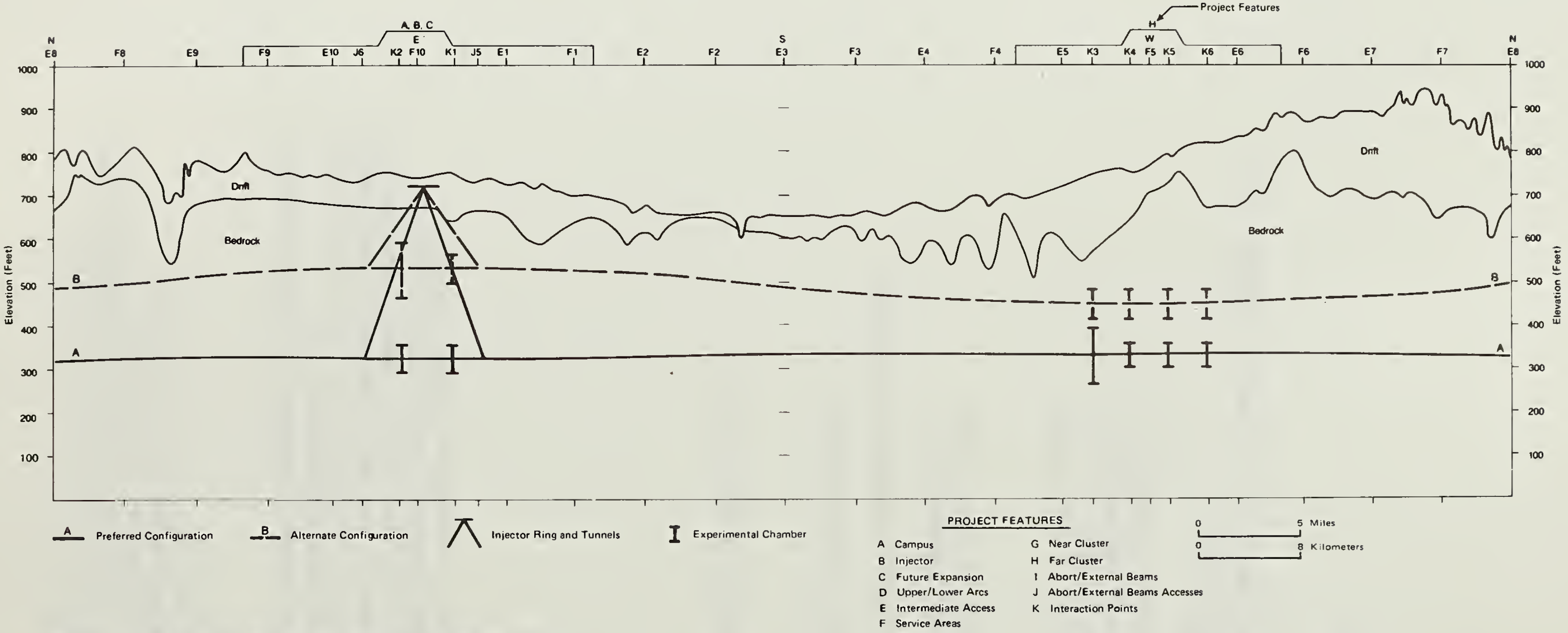


Figure 1 Profile of the Illinois SSC ring (State of Illinois, 1987)

EXECUTIVE SUMMARY

This study examines potential uses for the material that would be excavated if the proposed Superconducting Super Collider (SSC) is built in northeastern Illinois. Environmentally and economically sound uses for the excavated material are identified.

Of the construction options that were considered, placing the SSC in an underground tunnel was judged to be the best plan for minimizing impact on the cultural and natural environments. The tunnel will be placed in dolomite, which provides an excellent tunneling medium. About 94 percent of the material excavated during construction of the facility would be dolomite and dolomitic limestone. The remaining 6 percent would consist of dolomitic shale, glacial till, and sand and gravel. The expected total amount of material to be removed is about 4.1 million cubic yards (4.6 million tons). About 59 percent of this material would be produced by tunnel boring machines, about 38 percent would come from drill-and-blast excavation, and about 3 percent would be produced by clam-shell excavation of the glacial materials.

Five potential uses for the excavated material have been examined:

- use or storage in sand and gravel pits and rock quarries;
- restoration of the Kaneville Esker;
- landscaping around SSC campus and service areas;
- use in local forest preserves;
- use in local landfills.

Pits and quarries could easily accommodate all of the excavated material. (A survey indicated that the local aggregates operators would be willing to accept eight times the amount of material to be excavated from the SSC.) Restoration of the Kaneville Esker and landscaping could each use the majority of the material, and local forest preserves and landfills would use much less than the total 4.1 million cubic yards. All five options are environmentally sound and would benefit the surrounding communities.

INTRODUCTION

The Illinois Superconducting Super Collider (SSC) Geologic Task Force considered the size and orientation of the ring as it evaluated three construction options for the SSC tunnel: cut-and-cover at ground surface, a shallow tunnel in near-surface glacial materials, and a tunnel in bedrock. After a three-year drilling program, the Geologic Task Force concluded that a tunnel in bedrock is the best construction option. This option offers the advantages of well-understood, relatively homogeneous geology and a seismically stable setting for the facility's underground experimental chambers and its entire 53 miles of tunnel. The rock units have great strength and solidity--properties that will allow for a tunnel needing no systematic supports. In addition, the rocks are relatively soft and nonabrasive, so advance rates of boring machines will be high and cutter costs low.

Two tunnel ring configurations have been proposed (fig. 1). Ring configuration A is horizontal with an invert elevation of 320 feet above mean sea level (330 to 610 feet below the ground

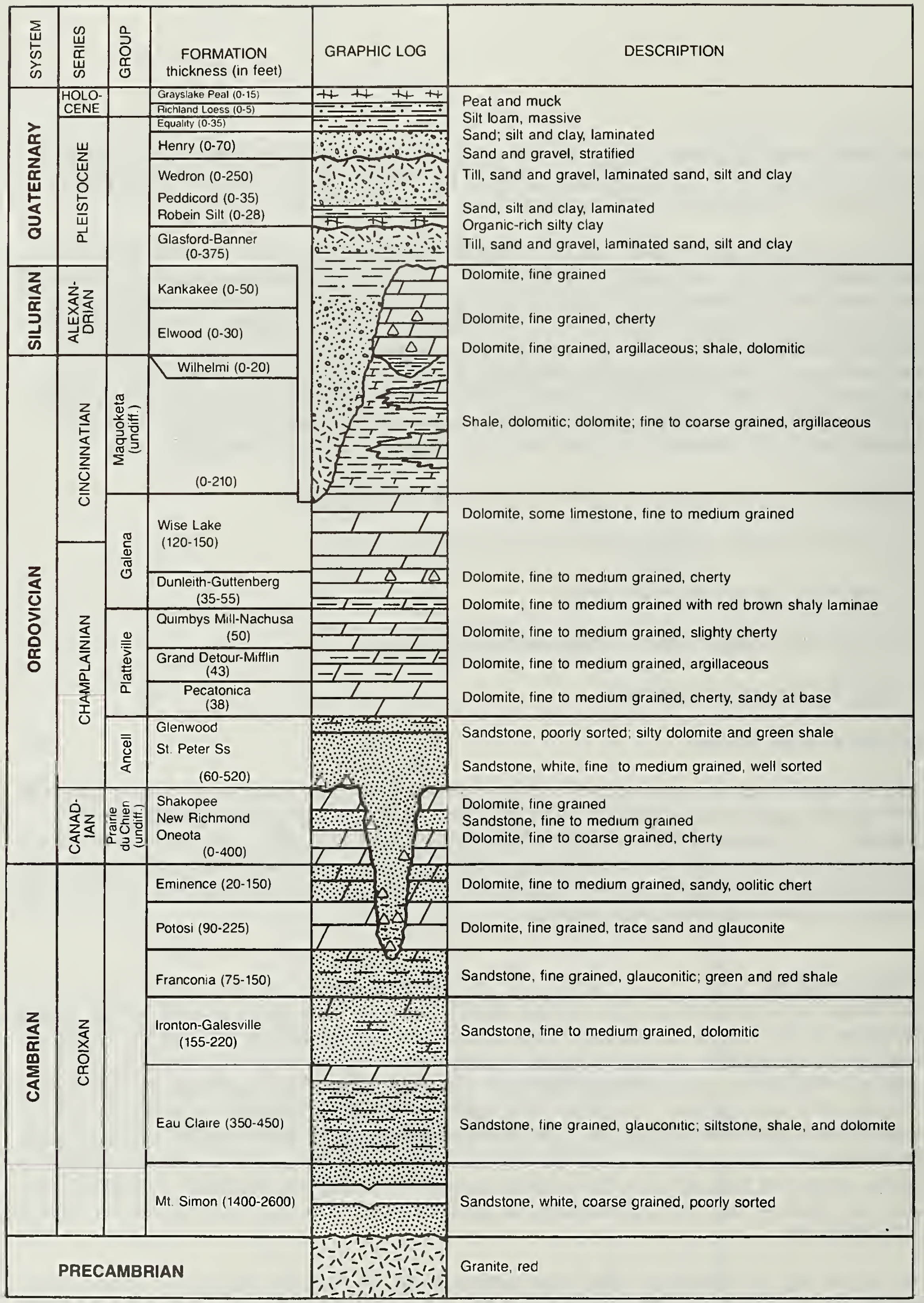


Figure 2 Stratigraphy of Paleozoic bedrock units in study area (Curry, 1988).

surface). This configuration meets the stated preference of the U.S. Department of Energy for a horizontal ring (U.S. DOE, 1987). Ring configuration B is presented as a feasible alternative that would minimize the depth of the ring. Configuration B introduces a downward tilt of 0.066 degrees to the west, resulting in an invert elevation of 528 feet near the main campus on the east and 435 feet at the far experimental areas on the west (the entire ring is 150 to 450 feet below ground surface). This alternative design was proposed to better meet the DOE's technical evaluation criterion: installation and operational efficiency resulting from minimal depths for the accelerator complex and experimental halls. This study concentrates on the horizontal ring (configuration A) because Illinois believes that the superior tunneling medium it provides (more pure dolomite and less dolomitic shale than configuration B) makes it the optimal design.

A great deal of information gained from two other large-scale tunneling projects in the region was used in examining potential uses for the material to be excavated from the Illinois SSC. The two projects were the Tunnel and Reservoir Plan (TARP) in Chicago and the Milwaukee Metropolitan Sewerage District's (MSD) cross-town interceptor and inline pump station project. Both of these tunneling projects are being constructed by tunnel boring machines (TBM) and drilling-and-blasting in geologic conditions very similar to those of the proposed Illinois SSC project: undeformed, generally thick beds of dolomite, dolomitic limestone, argillaceous dolomite, and interbedded dolomite and shale. The TARP project has produced more than 14 million tons of excavated material from the more than 72 miles of tunnel that had been constructed as of March 1987. The Milwaukee project has produced more than 1 million tons of excavated material from the 7 miles of tunnel constructed as of April 1988.

Disposal of the material excavated from the Chicago TARP was largely the responsibility of the TARP contractors. For the most part, the contractors stockpiled the material and used it for backfill on other construction projects, sold it at a low unit price, and gave it to municipalities to use on public projects. Some of the material was used to landscape around three of the main pumping stations of the project. Excavated material from the Milwaukee project has largely been used by the city as lakefill to combat erosion of the Lake Michigan shoreline.

DESCRIPTION OF MATERIAL TO BE EXCAVATED FOR THE SSC

Volumes and Tonnages of Material

Construction of the horizontal SSC facility (configuration A) would produce about 4.6 million tons (4.1 million cubic yards [CY]) of excavated rock and earth material (EREM), or about 4.4 million tons (3.8 million CY) for the tilted ring facility (configuration B). The reduced amount of material excavated from the latter design is due to the 39 percent decrease in total shaft length needed to serve the shallower tunnel. These volume estimates are based on a 12-foot diameter collider tunnel and a muck swell factor (the ratio of a given volume of excavated material to its in-place volume) of 2. The weight calculations were made assuming an average in-place density of the rock (dolomite, dolomitic limestone, argillaceous dolomite, and dolomitic shale) of 2.19 tons/CY and an average in-place density of the glacial till and sand and gravel of 1.6 tons/CY. The tonnage estimate was then increased by 5 percent to take into account both an increase in moisture from the tunnel boring machine (TBM) and precipitation at the surface.

The horizontal ring configuration yields a different composition of EREM than the tilted ring. The EREM composition for both ring configurations (table 1) is based on the geologic profile developed by the Illinois SSC Geologic Task Force from the results of their 1985-87 drilling program (Vaiden, 1987). The stratigraphic column of figure 2 describes the sediment and rock to be penetrated.

The tilted tunnel configuration would reduce the amount of dolomite, argillaceous dolomite, and dolomitic limestone by about 1.2 million tons and would increase the amount of dolomitic shale by about 890,000 tons.

Table 1 Composition of excavated material (percentage by volume)

Material	Horizontal tunnel (%)	Tilted tunnel (%)
Galena-Platteville dolomite	78.2	63.0
Galena-Platteville dolomitic limestone	15.0	0.1
Galena-Platteville argillaceous dolomite	1.0	10.4
Maquoketa dolomitic shale	2.7	23.2
Quaternary glacial till	2.2	2.3
Quaternary sand and gravel	0.9	1.0
	100.0	100.0

Particle Size and Shape

The particle size and shape of EREM is dependent on the method of excavation, the unmined material's mechanical and physical characteristics, and on the discontinuity spacing of the material in place. Because the geologic conditions and excavation methods of the Chicago TARP and the Milwaukee MSD tunneling projects are very similar to those proposed for the Illinois SSC, we can use these as examples to make inferences about the size and shape of the material excavated for the Illinois SSC project.

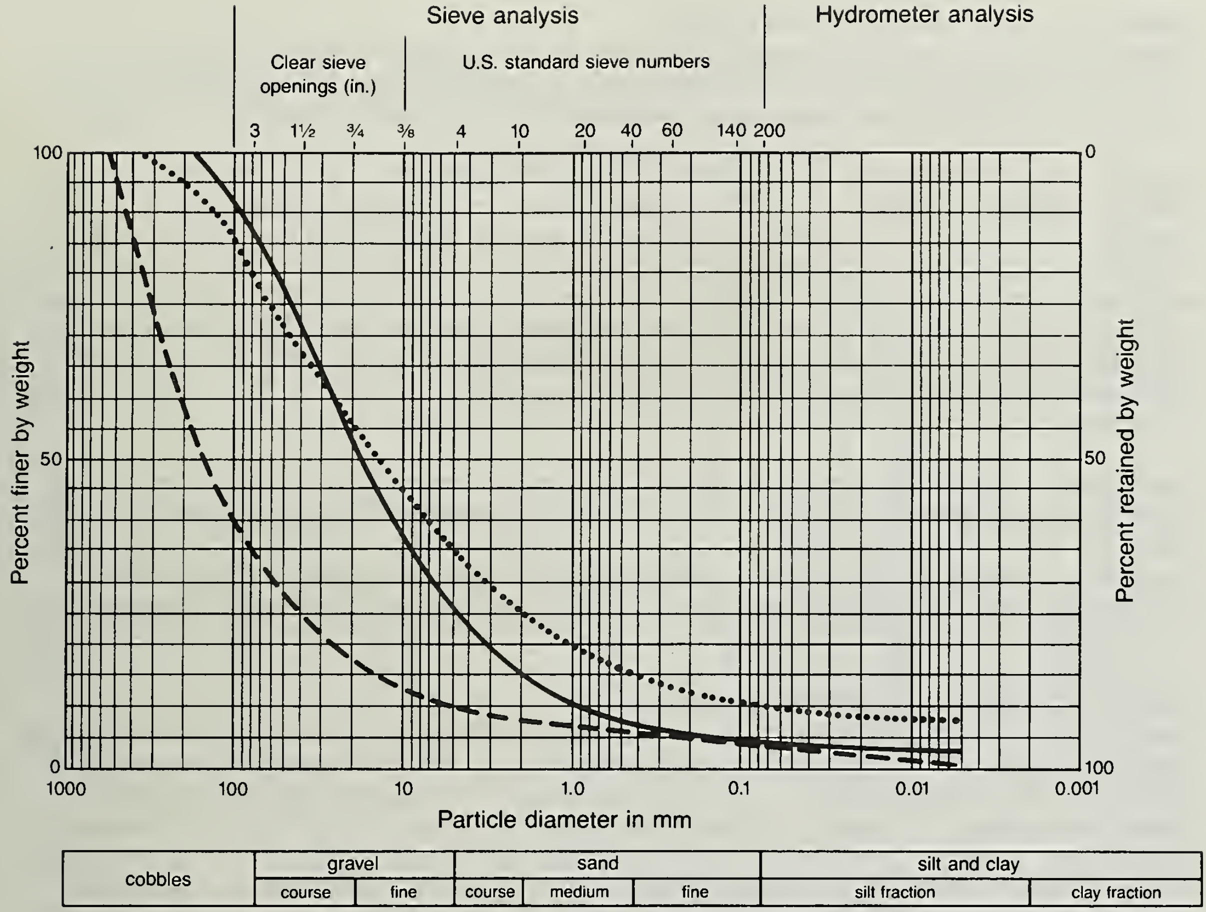
Tunnel boring machines (TBM) produced between 85 and 95 percent of the EREM from the Chicago TARP and Milwaukee MSD projects. Approximately 59 percent (2.4 million CY) of the EREM from the Illinois SSC would be produced by TBM, generated only from the 53-mile-circumference collider tunnel and the injector tunnels. Shafts in bedrock, experimental chambers, aborts, alcoves, and passing areas would be constructed by drill-and-blast excavation.

Table 2 Wet sieve analysis of tunnel boring machine spoil (converted Chicago TARP data)

Particle size	Weight (%)
> 100	0
< 100 mm > 75 mm	1.2
< 75 mm > 63 mm	0.9
< 63 mm > 50 mm	3.1
< 50 mm > 37.5 mm	3.7
< 37.5 mm > 25.0 mm	5.6
< 25.0 mm > 19.0 mm	2.4
< 19.0 mm > 12.5 mm	4.2
< 12.5 mm > 9.5 mm	11.1
< 9.5 mm > 6.3 mm	14.8
< 6.3 mm > 4.69 mm	16.5
< 4.69 mm > 2.36 mm	6.8
< 2.36 mm > 1.18 mm	3.0
< 1.18 mm > 600 µm	2.8
< 600 µm > 300 µm	3.0
< 300 µm > 150 µm	2.4
< 150 µm > 75 µm	1.5
< 75 µm	
TOTAL	100.0

Wet sieve analyses were conducted with dolomite excavated by TARP's tunnel boring machines to determine the material's range of particle size (table 2). This material has distinctive particles. Most are flat and elongated with a general thickness:width:length ratio of about 1:4:8 (IITRI, 1983). About 53 percent of the material is in the 2.36- to 19-mm size range. The flakiness of the material is due to the spalling fracture that a TBM produces as its rollers cut the rock.

Approximately 38 percent (1.6 million CY) of the EREM from the Illinois SSC (configuration A) would be produced by drill-and-blast excavation during the construction of shafts in bedrock, chambers, aborts, alcoves, and passing areas in bedrock. About 3 percent (122,000 CY) would be produced by clam-shell excavation from portions of the shafts. The shafts are constructed in glacial drift, which consists of firm beds of silty clays and loams (glacial till) and sand and gravel beds (glacial outwash). Shaft construction would penetrate an average of 100 feet of overburden at each site before reaching bedrock.



	Sample No.	Description	Coefficient of uniformity Cu	Number rock type
— — — —	54	cobbles and gravel	33	quartz monozonite
••••••••••	55	gravel with cobbles	12	siltstone and shale
————	56	gravel with cobbles	13	conglomerate

Figure 3 Gradation curves for drill-and-blast excavated rock (Liu et al., 1977)

Drill-and-blast excavation produced only 5 to 15 percent of the EREM from the Chicago TARP and Milwaukee MSD projects; no documentation on the particle size and shape gradation of this material was found. In general, drill-and-blast material to be excavated is expected to range in size from silt-size particles to boulders (<0.0025 to >10 inches in diameter). Size distribution is primarily dependent on the amount and spacing of the explosive charges, sequence and delays in detonation, number and orientation of joints, and the strength of the rock. Usually, contractors weigh the increased cost of removing larger rock pieces against the increased cost for greater fragmentation. Figure 3 shows gradation curves illustrating the proportions of different particle sizes produced during several rock tunnel excavations by drill-and-blast techniques. Three rock types are represented: quartz monzonite, siltstone and shale, and conglomerate (Liu et al., 1977). Of these three rock types, the dolomitic rock of the Illinois SSC project would probably most closely resemble the siltstone and shale curve.

USES FOR THE EXCAVATED MATERIAL

Important factors for evaluating potential uses for excavated material include the hauling distances involved, the suitability of the material for its proposed use, the ability of the user to adequately handle the material, and the cooperation with the parties involved.

Using the excavated material for landfill along Lake Michigan or for agricultural lime has been ruled out because of uneconomical transportation costs and probable unsuitability of the material. If the material from the Illinois SSC were used for landfill along the Lake Michigan shoreline, transportation costs of hauling the material more than 50 miles to the lake would be very high. Using the excavated material for the production of agricultural lime poses the same uneconomical transportation costs (the closest processing plant is more than 20 miles from the SSC site). Given the short-time supply of the material, it would be uneconomical to obtain the equipment and space necessary to set up a processing plant. In addition, the moisture content of the material is undesirable for the agricultural lime processing procedure.

Five feasible uses for the excavated material have been examined: (1) use or storage in pits and quarries, (2) restoration of the Kaneville Esker, (3) landscape in SSC campus and service areas, (4) use in forest preserves, and (5) use in sanitary landfills. All of these potential uses are economical from the standpoint of transportation--all users are within 10 miles of the proposed collider ring. Each has an environmentally sound use for the material. Initial contact with these users indicates full cooperation for planning the disposition of the excavated material.

Sand and Gravel Pits and Rock Quarries

Operators of 17 sand and gravel pits and rock quarries within the 16 townships surrounding the proposed Illinois SSC (T. 37-40N, R. 6-9E) have shown an interest in using the excavated material for reclamation and/or recrushing and blending. The locations of these pits and quarries are shown on figure 4. The only pits in figure 4 that do not fall under this category are pit/quarry numbers 9, 10, and 11, which are included in the plan as part of the restoration of the Kaneville Esker. Of the 17 operators interested in taking the excavated material, 15 have specified how much material they could handle. Their estimated demand for the material totals more than 40 million tons--over eight times the amount to be excavated (Curran, 1988).

Restoration of the Kaneville Esker

Kane County government proposes that the excavated material be used to restore the esker to its form before sand and gravel operations pitted and leveled it. Pre-excavation elevations were determined from a 1929 edition of a 15-minute topographic map. About 3.25 million CY of material is estimated to be needed for this restoration. The esker is located at the interchange of the East-West Tollway and Illinois Route 47. The 1,115 acres involved in the restoration would become a park (pit/quarry numbers 7, 8, 9, 10, and 11 of fig. 4). The local government plans for the park to provide fishing and swimming in several small lakes, and facilities for picnicking, cycling, and hiking. The park would be linked to the county's 60-mile trail system, making it possible to walk or bicycle on dedicated trails to many areas, including Fermilab and the Fox Valley.

Landscaping SSC Campus and Service Areas

This alternative is proposed as a way to eliminate much of the transportation involved with the other disposal options. The material would be used to landscape the campus and service areas adjacent to the shafts from which it is taken. A method for this type of landscaping was developed for the Chicago TARP project and could also be applied in restoring the Kaneville Esker. The procedure for this method is described in the Environmental Issues and Mitigation section of this report. Landscaping the excavated material from the TARP project around three of the main pumping stations proved to be an environmentally sound and aesthetically pleasing use for the excavated material. Landscaping of the excavated material from the SSC would provide similar benefits.

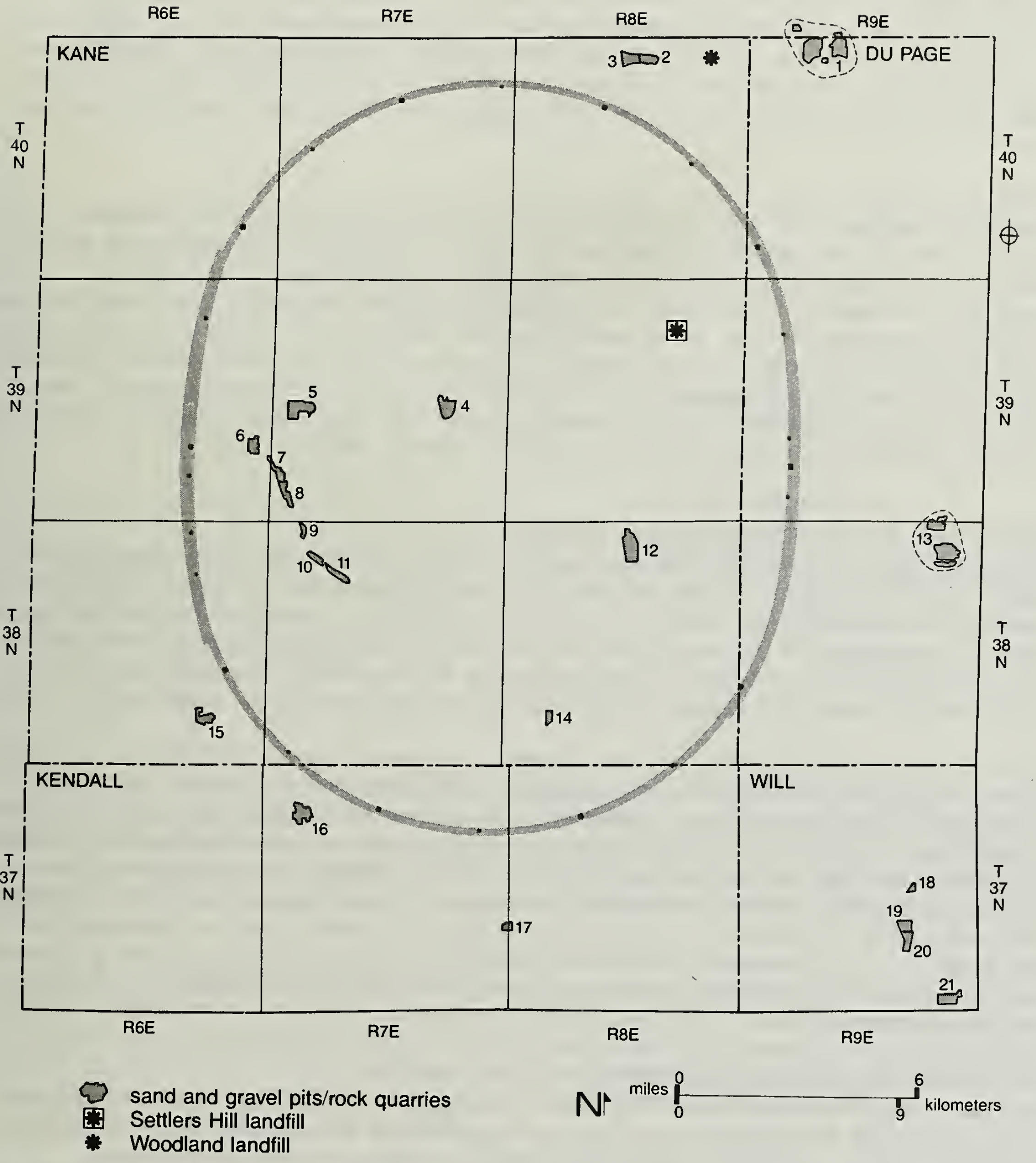


Figure 4 Location of sand and gravel pits, rock quarries, and sanitary landfills involved in the proposed uses for the excavated material

Forest Preserves
Administrators of the Du Page, Kane, Kendall, and Will County Forest Preserves have all shown an interest in the TBM excavated material. The preserves would use the material mainly for trail base. Other possibilities include use as fill material for alkaline habitat restoration and for building recreational hills. The Du Page County Forest Preserve received several hundred cubic yards of TBM material from the Chicago TARP project and found it very useful for trail base.

Sanitary Landfills
Three local sanitary landfills have expressed an interest in obtaining the TBM excavated material. Two of these landfills are identified on figure 4 (Settlers Hill and Woodland), and the third (Green Valley) is about three miles east of the 16-township area (Green Road in Naperville). The landfills would most likely screen the material into several sizes, using the finer particles to cover and line the landfill and the coarser particles for surfacing their internal haul roads. The Municipal Environmental Research Laboratory of the U.S. Environmental Protection Agency has found that using fine-grained limestone and dolomite in landfills slows the rate at which heavy metals (arsenic, beryllium, cadmium, chromium, iron, nickel, selenium, vanadium, and zinc) leach through the soil (American City and County, 1981).

COSTS FOR EXCAVATED MATERIAL USES

The current assumption is that pits and quarries, sanitary landfills, and county forest preserves would accept the material. No disposal fee would be charged to the SSC project nor would the receivers be charged for the excavated material. In addition, it is assumed that the SSC project would be responsible for delivery of the material; and the receiving pits and quarries, landfills, and forest preserves would assume responsibility for all other costs necessitated by their use of the excavated material (i.e., spreading, landscaping, sorting, blending, or recrushing).

Under the current assumptions, once the material is removed from the SSC facility, the primary costs to the project for using the options of pits and quarries, sanitary landfills, and forest preserves are transportation, road upgrading, and road maintenance costs. For the alternative of using the material to landscape campus and service areas, minor transportation and related road costs would be incurred if landscaping in the campus areas extended outside of the areas adjacent to the shaft. But for the most part, the costs of this alternative would be in spreading and revegetating the material. The costs of restoring the Kaneville Esker would include the acquisition of 1,115 acres and 13 structures, spreading the excavated material with a bulldozer, and revegetating the landscaped area in addition to transportation and related road upgrading and maintenance costs.

NETWORK Transportation Cost Model
Transportation is the primary cost for most of the proposed disposal alternatives. A model to plan for minimum transportation costs and hauling distances is being used on the Geographic Information System (GIS) of the Illinois Department of Energy and Natural Resources. NETWORK, a subsystem of the ARC/INFO software on the GIS, is a collection of commands designed to simulate the flow of resources along links to centers in a network, such as water along streams to reservoirs or trucks along roads. The network in this model consists of the roads in the SSC area; the resource is the rock material; and the distribution centers are the pits and quarries. Given the amount of resource to be removed from each shaft, the model finds the shortest route to the closest pit or quarry that can hold that amount of resource. Assuming that transportation cost is proportional to haul distance, the shortest route means the lowest cost. Costs of different alternatives can be compared quickly by changing the parameters for resources and centers.

The NETWORK model was used to estimate transportation costs and designate hauling routes for the two alternatives that can accommodate the entire 4.6 million tons of excavated material:

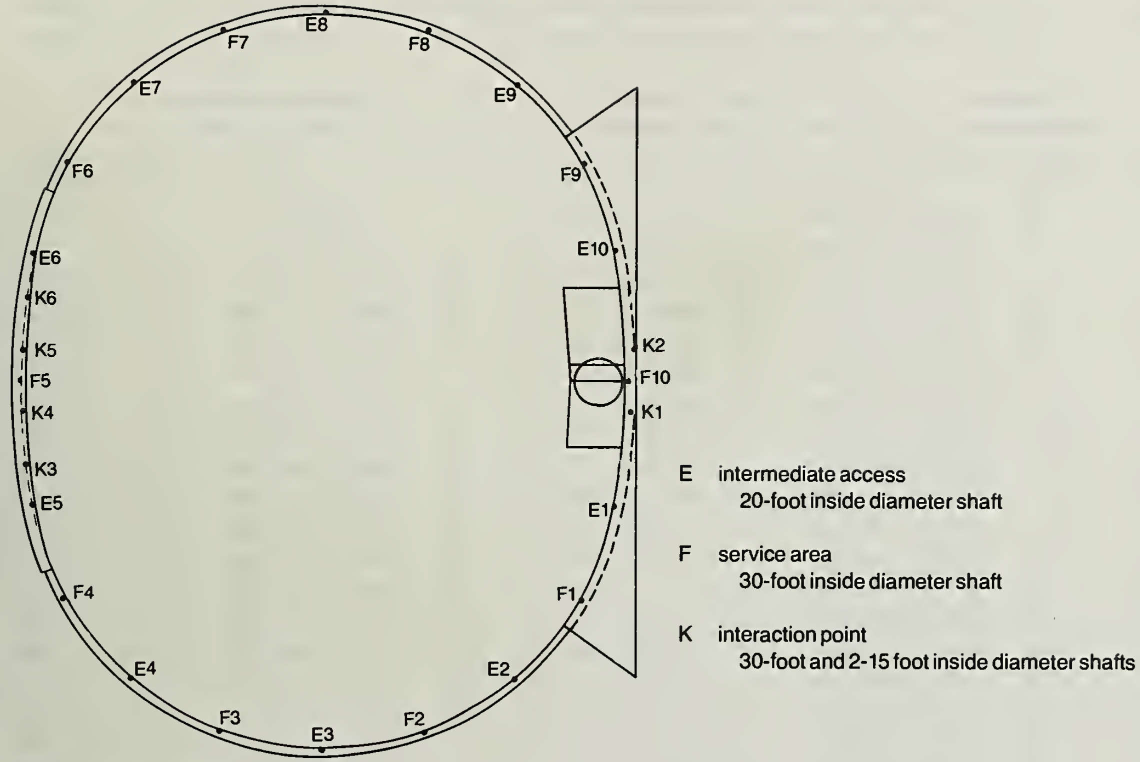


Figure 5 Plan view of SSC ring

(1) the 17 sand and gravel pits and rock quarries interested in the material, and (2) the Kaneville Esker project. (Restoration is estimated to require only 3.25 million CY of material; the remaining 1.15 million CY can be distributed to the closest of the 17 pits and quarries.) Only those roads that the Illinois Department of Transportation specified for hauling were included in the network; state roads were to be used whenever possible and main streets of communities were to be avoided.

All access shafts planned for the SSC were used in the model for resource removal (fig. 5), although the selection of shafts to be used during actual excavation would be based on minimal disturbance to the surface environment. The SSC has ten 20-foot, fourteen 30-foot, and eight 15-foot inside diameter (ID) shafts. Although the larger 30-foot ID refrigeration (F-series) and equipment drop (K-series) shafts would generally be preferred for EREM removal, the smaller 20-foot ID exit/vent shafts can also be used.

After the model was run, transportation costs were calculated by applying a cost function to the total distance of each hauling route: $/ton = 1 + 0.09 x (distance of hauling route). This function was derived by running a least-squares linear regression analysis on trucking cost data ($/ton per distance traveled in miles) collected from several sources describing activity closely comparable to the hauling of the material excavated from the SSC (Milwaukee Metropolitan Sewerage District, 1983; IITRI, 1983; Bhagwat, 1986; Dirkes, 1987).

The estimated transportation cost for the alternative using the 17 sand and gravel pits and rock quarries is $7.0 million; the transportation cost for restoring the Kaneville Esker is estimated at $8.8 million. Tables 3 and 4 present more detailed results of the NETWORK models for these two alternatives--including volume and tonnage of material transferred along each handling route and the distance and total transporation costs for each route.

Table 3 NETWORK results: transportation costs for hauling material excavated for the Illinois SSC using 17 sand and gravel pits and rock quarries

Shaft	Destination pit/quarry no. (fig. 3)	Volume transferred (CY)	Tonnage transferred (tons)	Miles traveled one way	Transportation cost per shaft* (total)
E1	13	141.114	161,546	7.4	$269,000
E2	7	131,758	150,919	6.8	243,000
E3	16	131,194	150,428	5.5	225,000
E4	15	131,898	150,950	3.8	203,000
E5	9	141,082	161,028	6.2	251,000
E6	6	144,326	164,566	4.7	234,000
E7	5	137,962	156,874	6.6	250,000
E8	3	135,424	154,654	4.9	223,000
E9	1	134,944	154,277	6.8	249,000
E10	13	141,928	162,630	8.2	282,000
F1	13	151,318	172,869	9.2	316,000
F2	7	150,424	172,727	4.2	237,000
F3	16	149,828	171,488	2.6	212,000
F4	15	159,970	181,432	6.8	292,000
F5	6	164,732	188,200	2.5	231,000
F6	5	163,118	185,808	6.6	296,000
F7	3	166,516	186,374	8.2	324,000
F8	2	158,172	180,657	2.9	228,000
F9	2	164,438	187,861	8.5	332,000
F10	13	454,118	520,681	5.8	792,000
K1	13	199,126	225,783	5.4	336,000
K2	13	199,126	226,740	6.6	361,000
K3	6	205,436	231,125	4.8	331,000
K4	6	206,558	234,300	3.2	302,000
TOTALS		4,064,510	4,633,917		$7,019,000

*Cost calculations are rounded to the nearest $1,000.

POTENTIAL EFFECTS ON THE AGGREGATES MARKET

Annually, 19 operators produce more than 4 million tons of sand and gravel and more than 3 million tons of dolomite in the 16 townships surrounding the proposed Illinois SSC facility (T37-40N, R6-9E) (Curran, 1988). Because the SSC project will produce an estimated 4.6 million tons of EREM over a 30-month period, potential effects that this material would have on the local aggregates market must be examined.

The total weight of excavated sand and gravel (from the glacial drift material) will be about 30,000 tons. Most of this material will be generated in the first year of the project as the shafts are excavated from the surface through the glacial till. Given the intermittent small amounts of sand and gravel that will be taken from the shafts, not much is likely to be added to the market supply. Even if all of this sand and gravel were added, the market impact would be negligible because the current annual production in the 16-township area is more than 4 million tons.

About 4.4 million tons of dolomite, argillaceous dolomite, and dolomitic limestone would be excavated over the 30-month construction period. Because the annual production in the 16 townships surrounding the proposed site (>3 million tons) is about 70 percent of this amount, consultation with the local aggregates producers is underway to ensure that the material will not negatively impact the aggregates market. Several factors (in addition to the fact that most of

Table 4 NETWORK results: transportation costs for hauling material excavated for the Illinois SSC to restore the Kaneville Esker

Shaft	Destination pit/quarry no. (fig. 3)	Volume transferred (CY)	Tonnage transferred (tons)	Miles traveled one way	Transportation cost per shaft* (total)
E1	13	141,114	161,546	7.4	$269,000
E2	10	131,758	150,919	14.7	351,000
E3	10	131,194	150,428	10.6	294,000
E4	11	131,898	150,950	6.3	237,000
E5	9	141,082	161,027	4.8	231,000
E6	7/8	144,326	164,566	5.3	243,000
E7	7/8	137,962	156,874	9.7	294,000
E8	7/8	135,424	154,655	16.0	377,000
E9	7/8	134,944	154,277	17.7	400,000
E10	7/8	141,928	162,629	16.3	401,000
F1	10	141,701	161,188	17.2	411,000
F1	13	9,617	11,681	9.2	21,000
F2	10	150,424	172,727	14.9	404,000
F3	11	83,746	95,510	7.0	156,000
F3	10	66,082	75,978	7.6	128,000
F4	10	137,922	156,083	4.8	224,000
F4	9	22,048	25,250	5.5	38,000
F5	7/8	164,732	188,200	3.1	241,000
F6	7/8	163,118	185,808	9.7	348,000
F7	7/8	166,516	186,374	12.9	403,000
F8	7/8	158,172	180,657	17.5	465,000
F9	2	164,438	187,862	8.5	332,000
F10	7/8	142,515	163,404	18.1	430,000
F10	13	311,603	357,277	5.8	544,000
K1	13	199,126	225,783	5.4	336,000
K2	7/8	199,126	226,740	17.6	586,000
K3	9	205,436	231,125	3.6	306,000
K4	7/8	206,558	234,300	3.9	317,000
TOTALS		4,064,510	4,633,917		$8,787,000

*Cost calculations are rounded to the nearest $1,000.

the proposed uses preclude selling the excavated material) would buffer the local crushed stone market from being negatively impacted by the supply of excavated dolomitic material generated from the Illinois SSC facility.

First, 59 percent of the excavated material will be produced by TBMs. The size and shape of this material limits its use. The Illinois Institute of Technology Research Institute (1983) estimated the cost of processing the TBM rock from the Chicago TARP project to meet CA-6 gradation would be $7.13 per ton; this product sold for $3.75 per ton at the time of the study. Therefore, there is a very limited potential for marketing for the TBM material other than slowly blending it with quarry rock. Second, the drill-and-blast material--which is more suitable to make stone products--would probably not drastically increase the quarries annual production rates. Given the fact that the material coming from the SSC is a one-time supply (over a 30-month period), the operators are unlikely to make the investment needed to sharply increase their production rate capacities. However, all have space to stockpile SSC EREM for an extended

Table 5 Potential sources of particulate matter due to Illinois SSC construction

Source	Description	Level of particulate emission (tons/yr)
1) Roads	Paved hauling roads used to transport material to and from the construction site	Insignificant
2) Handling excavated material	Dust can be caused by four source operations in the storage cycle:	
	a) loading of aggregates into storage bins or piles	0.11
	b) equipment traffic in storage areas	included in 3
	c) wind erosion of pile surfaces	33.0
	d) loadout of aggregates for shipment	0.11
3) Surface construction	Earth movement for surface construction, excavation, and regrading	120.0
Total		153.22

period of time and so can pace their use of it to extend their resources and reclaim their pits. Third, if the SSC does come to northeastern Illinois, there will be an increased demand for aggregates material from the construction of the SSC and from the continuing growth of the surrounding area. About 220,000 CY of rock fill and 139,000 CY of concrete is estimated to be needed for the construction of only the underground facility (Harza, 1986).

ENVIRONMENTAL ISSUES AND MITIGATION

Potential adverse environmental effects on air and water quality associated with disposal of excavated material can easily be mitigated. Careful planning by the Illinois Department of Energy and Natural Resources has ensured that air and water quality would not deteriorate because of the disposal of excavated material from the SSC.

Air Quality

The construction of the SSC would be of no significant consequence on air quality in the area, and operation of the SSC would have no effect. The only possible construction effects are regarded as insignificant and relate to use of construction equipment and construction-related traffic and generation of dust from excavated material. Preliminary calculations, using a worst-case scenario to estimate the quantity of material that could be eroded into the air, indicate that the impact would be below permitting standards set by the U.S. Environmental Protection Agency (U.S. EPA).

Potential fugitive dust sources from construction activities at the SSC site are listed in table 5. These are the only factors that could potentially change total suspended particulate values in the SSC area. An analysis of SSC related activities (Barnard et al., 1986) shows that under the worst conceivable conditions, 153 tons per year of particulate matter could be emitted during a three-year construction phase. Even this worst case is well below the 250 tons per minimum level that requires permitting. Since this 153 tons per year represents the accumulated total produced over the entire SSC site and would not be derived from a single construction site, it is apparent that the project would not significantly affect levels of total suspended particulates.

Water Quality
Krapac et al. (1988) have shown that excavated material would produce innocuous leachates that resemble local groundwater in composition. Their study reported that the pH of the material's extracts range from 7.6 to 10.1, and the mean constituent concentrations of all extracts were below drinking and surface water standards set by the Illinois Environmental Protection Agency (IEPA). The higher pH values (>9.0) were associated with the dolomite and limestone samples. The pH of these samples is expected to decrease as the system equilibrates with calcite--the pH of a system containing $CaC0_3$ in water in equilibrium with the atmosphere is 8.4 (Garrels and Christ, 1965). This lower expected pH level of dolomite and limestone extracts is supported by the fact that the IEPA has never found runoff water from any of the dolomite and limestone quarries in northeastern Illinois to have pH values greater than 9.0 (Cima, 1988).

Thus, the material to be excavated for the Illinois SSC can be expected to produce about the same nonhazardous leachates as rain does percolating through native soil and crushed dolomite and limestone spread on many gravel roads and driveways. The harmless nature of similar dolomitic material excavated from the Milwaukee MSD project has enabled the city to use the material for lakefill (Meinholtz, 1988).

Although the excavated material is harmless, the Illinois state government would take precautions to ensure that the material's finer particles did not run off where the material was piled for stockpiling and reclamation purposes. Consequently, the fine particulate matter would not muddy the surface water. For the portion of the material taken to operating sand and gravel pits and rock quarries, the sediment control system is in place through the IEPA. Each operator must have a National Pollution Discharge Elimination System (NPDES) permit from IEPA for discharge. The IEPA monitors each discharge site weekly to monthly for pH and total suspended particulates.

Potential runoff from fine-grained excavated material used for landscaping or reclaiming abandoned sand and gravel pits would be mitigated using methods developed for the Chicago TARP project. Three of the main pumping stations were landscaped with excavated dolomitic material, which was used to prevent fine-material runoff. First, all topsoil was removed down to a clayey layer. The excavated material was placed on this base, then completely covered with additional clay and 2 to 3 feet of topsoil. Finally, the area was revegetated with woody plants, no-mow grasses, and flowers.

BENEFITS OF EXCAVATED MATERIAL USES

The surrounding communities would benefit from any of the proposed uses for the excavated material. Using the material for reclamation of pits and quarries and to landscape around campus and service areas would enhance wildlife habitat by providing cover and food for many species. By restoring the Kaneville Esker, the forest and prairie habitat would be reclaimed and recreational opportunities (such as fishing and swimming) would be provided for the public. One of the local forest preserves has suggested using some of the excavated material to create a kind of wetland area called "alkaline fen," further increasing the diversity of habitat types that could be expanded in conjunction with the project. As noted previously, additional environmental benefit would be provided if some of the dolomitic TBM material were used for covering and lining local landfills. EPA studies show that the use of fine-grained limestone and dolomite slow the leaching of heavy metals in sanitary landfills (American City and County, 1981).

Economic benefits could also be gained. Inexpensive surfacing and fill material could be provided to the local forest preserves. In addition, the life expectancy of active sand and gravel pits and rock quarries could be extended by the portion of the excavated material that could be used for blending and reclamation purposes.

CONCLUSIONS

The five potential uses for the material excavated for the Illinois SSC share these advantages:

- economical transportation costs--all potential users are located within 10 miles of the proposed collider ring;

- suitable, environmentally safe uses for the material;

- cooperative attitudes of potential users.

Using the excavated material in pits and quarries could easily accommodate all of the material; a survey indicates that the local aggregates operators would be willing to accept eight times the amount of material to be excavated from the SSC (Curran, 1988). Restoration of the Kaneville Esker and landscaping could each use most of the material, and local forest preserves and landfills would require much less than the total 4.1 million cubic yards. Because the demand created by these five uses exceeds the supply of excavated material to be generated by the project, careful consideration of the trade-offs between the public benefits and the costs must be considered in deciding which uses should be implemented.

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GLOSSARY

Adit, a horizontal or tilted horseshoe-shaped bypass tunnel of the SSC.

Argillaceous dolomite, dolomite determined by examination or analysis to contain 25- to 50-percent mud (clay or silt or a mixture of both) as interbedded thin layers or films or disseminated in the rock mass.

CA-6 gradation, Illinois Department of Transportation construction aggregates classification, defined in terms of percentages of aggregates passing given sieve sizes; specifically, 100 percent through a 1.5-inch sieve, 90 to 100 percent through a 1.0-inch sieve, 60 to 90 percent through a 0.5-inch sieve, 35 to 55 percent through a no. 4 sieve, 10 to 40 percent through a no. 16 sieve, and 4 to 12 percent through a no. 200 sieve.

Dolomite, a sedimentary rock determined by examination or analysis to contain at least 75 percent of the mineral dolomite, $CaMg(CO_3)_2$.

Dolomitic limestone, a sedimentary rock that is at least 50-percent calcite ($CaCO_3$) mixed with 10- to 50-percent dolomite.

Esker, a long narrow ridge of irregularly stratified sand and gravel deposited by a stream flowing below or between glacial ice or in an ice tunnel of a stagnant or retreating glacier.

Glacial till, sandy and gravelly muds deposited by glaciers with little or no modification by meltwater as the ice flows and melts down.

Invert elevation, the elevation of the floor of the excavated collider tunnel.

Joint, a surface or fracture in a rock without shear displacement; the surface is usually a rough plane and often occurs with parallel joints to form part of a joint set.

Land easement, a right afforded to a party to make limited use of another's land, as the right of way (e.g., to permit use of the easement area to bury a cable).

Leaching, the process by which a liquid percolating through material dissolves part of it and carries it away.

Least-squares regression analysis, a statistical technique to determine from all possible regression lines, the line that minimizes the sum of squared deviations from the line.

Muck swell factor, the ratio of a given volume of excavated material to its volume in place (if 1 cubic yard of rock in place yields 2 cubic yards of mined rock, the ratio of the volumes is 2:1 and the muck swell factor is 2).

Shale, a thinly layered mudrock, composed of clay or silt or a mixture of both that splits into plates or chips.

Spalling fracture, curved fracture produced by pressure on a rock surface that results in flake-like pieces of rock.

Wet screen analysis, determination of the particle-size distribution of a disaggregated sediment or rock by washing the sample through a stack of progressively finer screens and measuring the percentage of material retained on each screen.